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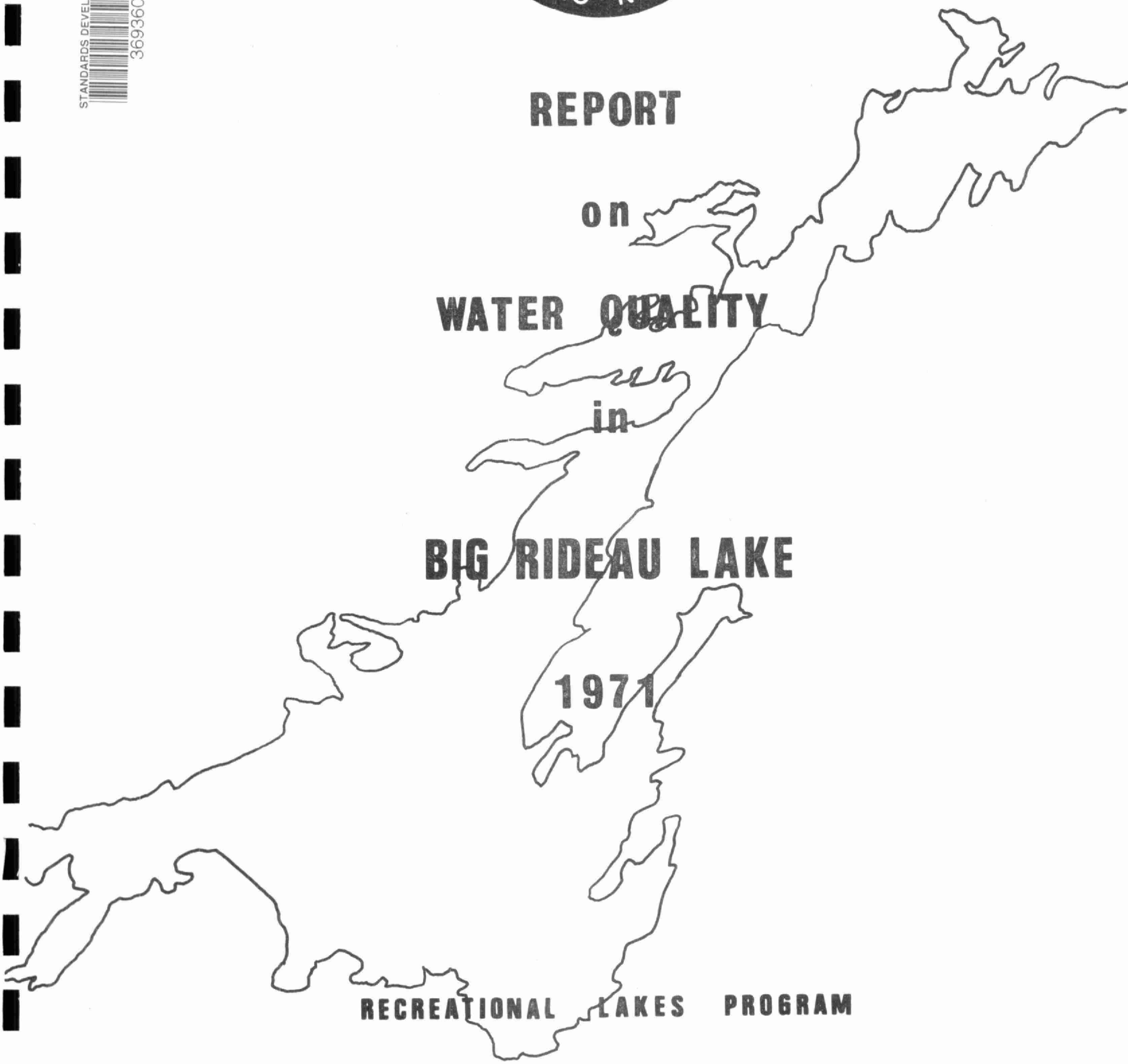
ONTARIO WATER RESOURCES COMMISSION



REPORT

on

WATER QUALITY

in

BIG RIDEAU LAKE

1971

RECREATIONAL LAKES PROGRAM

BBDA

Environment Ontario

THE

ONTARIO WATER RESOURCES COMMISSION

REPORT

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SUMMARY

A study to evaluate the status of water quality in Big Rideau Lake was carried out during the summer of 1971.

Big Rideau Lake lies within the Precambrian Shield. The area is characterized by an irregular topography, good local drainage and shallow overburden covering Precambrian bedrock. There is generally a thin layer of a variety of top soils ranging from fine sandy loams to coarse gravely loams mixed with areas of black muck. The soil is exceedingly stony with rock outcrops dominating most of the shoreline. Due to the nature of the soils and the topography surrounding the lake, much of the shoreline is unsuitable for cottage development utilizing standard subsurface septic tank systems.

During June, three distinct temperature zones with respect to depth characterized the waters of only one mid-lake station. Thermal stratification was noted at all deep-water sampling sites during surveys conducted in July and October. Dissolved oxygen concentrations in the bottom waters were suitable for the maintenance of cold-water species of fish.

Big Rideau Lake is relatively hard and contains no unusual mineral characteristics. Usually surface pH readings were higher than bottom water readings. During the July and October surveys, pH values in the upper strata exceeded the criteria for public surface water supplies and recreational use. pH values above 8.3 may cause eye irritation to swimmers. Moderate accumulations of carbon dioxide were apparent in the bottom waters particularly at thermally stratified stations. The lower deep water pH values and moderate carbon dioxide accumulations were related to conditions of organic decomposition.

Algal levels, as measured by chlorophyll a concentrations, were low during all three surveys and would not be expected to reduce severely water-oriented recreational activities or diminish the aesthetic quality of the lake.

Kjeldahl nitrogen and total phosphorus concentrations were low and would not be expected to support nuisance levels of algae.

Generally, the bacteriological water quality of Big Rideau Lake was good and well within the OWRC recreational use criteria. Significant bacterial inputs were recorded around the towns of Portland and Rideau Ferry.

In order to maintain the present water quality of the lake, every effort should be made to ensure that direct flow or leachate from domestic waste disposal systems or other potential sources of pollution do not gain access to the lake.

INTRODUCTION

Maintenance of good water quality in recreational lakes in the Province of Ontario is of vital concern to the Ontario Ministry of the Environment and other governmental agencies involved in tourism and the control and management of shoreline development of cottages and resorts. In 1970 an interdepartmental program was established to survey a number of recreational lakes in order to detect and correct sources of water pollution and ensure that our lakes would be well managed to protect water quality. The Ontario Department of Health, whose jurisdiction in this program was transferred to the Ministry of the Environment, would carry out on-shore inspection and correction of faulty private waste disposal systems, whereas the Ontario Water Resources Commission (now within the Ministry of the Environment) would evaluate the existing water quality of the respective lakes. A record of the present status of the private waste disposal systems and the lake water quality would also be documented for comparative use in any future studies.

Recreational lakes are subjected to two major types of water quality impairment; bacteriological contamination and excessive growths of algae and aquatic weeds (eutrophication). The two problems may result from a common source of wastes but the consequences of each are quite different. Bacteriological contamination by raw or inadequately treated sewage poses an immediate public health hazard if the water is used for bathing. In order for this to occur, these wastes must gain entry to the lake although it may not be obvious upon visual inspection of the site. It must be noted that no surface water is considered safe for human consumption without prior treatment including disinfection. The algae and weed growths impair aesthetic values and recreational use of the lake but seldom pose a health hazard. There are nutrient sources other than sewage wastes which do not create serious bacterial hazards but do support nuisance plant growths such as agricultural fertilizer losses and normal nutrient runoff from forest and field.

In order to carry out its responsibility of evaluating the status of water quality in recreational lakes, the Ontario Water Resources Commission undertook a study on Big Rideau Lake in the summer of 1971. Three surveys were conducted; a spring survey from June 3 to 7, a mid-summer survey from July 29 to Aug. 2,

and a fall survey from October 12 to 15 inclusive. These studies included the assessment of bacteriological, physical, chemical and biological conditions of the lake with stress being placed on the bacteriological and nutrient enrichment problems.

Five consecutive days of sampling for each survey is normally required for a reliable assessment of bacteriological conditions. However, due to technical difficulties Big Rideau Lake was only sampled for four days during the fall survey.

In addition to the results obtained from these studies, information from other governmental agencies has been incorporated in this report which is the Ontario Water Resources Commission's contribution to the Interdepartmental Task Force Report which will deal with the overall cottage pollution program in Ontario.

AREA DESCRIPTION

Geography and Topography

Big Rideau Lake is located in the Townships of North Burgess and North Elmsley, (Lanark County) and the Townships of South Burgess, South Elmsley, Bastard and North Crosby, (Leeds County). The lake spans Narrows Lock and the community of Rideau Ferry, approximately 11 kilometers (7 miles) southwest of Smith Falls.

Big Rideau Lake is a long narrow lake with a wide area near the south end, being shaped somewhat like a ladle. It is about 20 kilometers (12.5 miles) long and is 6.5 kilometers (4 miles) at its widest point. The lake has a depth of 95 meters (312 feet) and a shoreline length of 172 kilometers (107 miles). The surface area of the lake covers an area of 24 square kilometers (9 square miles).

The immediate watershed of the lake excluding waters flowing from Upper Rideau Lake and Black Lake consists of 184 square kilometers (71 square miles) of land characterized by sandy loam soils and rock outcrop. The five basic soil types surrounding the area are; Farmington, Tweed sandy loam - Rock Complex, Monteagle sandy loam - Rock Complex, Tennyson and Muck. The Farmington loam and sandy loam series occupy the area between Narrows Lock and the mouth of Briton Bay along the south shore of Big Rideau Lake and the area in McVeetys Bay. This soil series has a thin gently sloping glacial till over a crystalline limestone bedrock. The Tweed sandy loam - Rock Complex is located along the east shore of Briton Bay, between Houghton Bay and the south half of O'Mearas Bay, between Narrows Lock and the south shore of Noble Bay and along the west shore of McLearns Bay. This soil complex generally consists of an exceedingly stony, thin, sandy loam, calcareous till overlying a bedrock formation of Precambrian Limestone. The soil is well-drained, with the water percolating readily through the soil or running rapidly off the slopes.

The Monteagle sandy loam - Rock Complex is located: between the west and north shores of Noble Bay and the entrance to Adam Lake; along the shores of Jacklins Bay to the east shore of Davidsons Bay; and the peninsula of land forming the west shore of Briton Bay. This soil complex consists of Monteagle sandy loam, Monteagle sandy loam - shallow phase, Muck, Christy sandy loam and several others of the sandy loam type. The soil, a greyish sandy loam till derived from granitic rock, is overlying Precambrian igneous and metamorphic bedrock, acidic in nature. The topography is irregular and steeply sloped and has good drainage. Small areas of the Tennyson sandy loam series of soils are found along the shoreline of Big Rideau Lake. This series is a Grey Brown Podzolic, well drained, calcareous, sandy loam till derived from greyish limestone and sandstones. The moisture percolates readily through the coarse soil materials or runs off the gentle slopes.

The north end of Big Rideau Lake consists of the Muck series of soil. This series is made up of organic deposits found in old glacial spillway channels and other depressional areas. Generally there is 46 centimeters (18 inches) or more of organic material overlying the mineral soil. The organic material is the partially decomposed remains of sedges and trees.

Climatic Range

The area has a mean daily temperature of $-9^{o}C$ ($16^{o}F$) in January and a mean daily temperature of $20^{o}C$ ($68^{o}F$) in July. The mean annual precipitation is 84 centimeters (33 inches) including 200 centimeters (80 inches) of snow. According to meteorological reports, the area enjoys about 250 days yearly of no measurable precipitation. The summer climate is conducive to most recreational activities and the winter with its abundance of snow provides for participation in most winter sports.

Water Movement

Big Rideau Lake lies in the Ottawa River Terminal Drainage Basin and is fed by three main sources: Upper Rideau Lake, which flows into Big Rideau Lake at

Narrows Locks; Black Lake, which flows into Hoggs Bay of Big Rideau Lake via the Black Creek; and Adams Lake which is fed by Long Lake. The only outflow is into Lower Rideau Lake at the north-east end of Big Rideau Lake by the community of Rideau Ferry.

Shoreline Development

The shoreline of Big Rideau Lake is well developed except for the west shoreline between Noble Bay and Narrows Lock. This area has less than 75 cottages scattered along 29 kilometers (18 miles) of shoreline while the rest of the shoreline has approximately 2425 closely spaced cottages (Figure 1). There is a yacht club located just north of the Police Village of Portland and a trailer camp across from Donovans Point on the west shore.

Water Usage

Most of the cottagers use the lake as their source of domestic water supply. The lake supports recreational water sports such as fishing, boating, water-skiing and swimming. According to information available from the Ministry of Natural Resources, the lake offers a sport fishery of lake trout, northern pike, largemouth bass, smallmouth bass and walleye. The coarse and common fish in the lake are perch, rock bass, crappies, pumpkinseed, bluegills, bullheads and suckers.

At the present time there are no direct discharges of raw or treated wastes into Big Rideau Lake from municipal or industrial sewage treatment facilities. The area residents are provided with a municipal solid waste disposal site located within 1.6 kilometers (1 mile) of the lake on part of Lots 26 and 27, Concession I, Township of South Crosby. This disposal site does not appear to be posing any pollution hazard to the lake.

FIGURE 1

LEGEND

- 59 - SAMPLING STATION Nº
- C - CHEMICAL SAMPLE
- P - PROFILE
- CH - CHLOROPHYLL SAMPLE
- D - DEPTH STATION

ONTARIO WATER RESOURCES COMMISSION	
1971 RECREATIONAL LAKES PROGRAM RIDEAU LAKE	
SCALE: 1" = 3000 FEET	
DRAWN BY: R.S.	DATE: MAY 1971
CHECKED BY:	DRAWING Nº: 71-44-DE

FIELD AND LABORATORY METHODS

Physical, Chemical and Biological Field Methods

Water quality surveys were conducted on Big Rideau Lake from June 3 to 7, July 29 to August 2, and October 13, 14, 15 and 27. Six near-shore stations (1, 19, 20, 31, 52 and 60), which are adjacent to inlets and outlets, as well as four mid-lake stations (18, 57, 58 and 59) were selected for physical, chemical and/or biological sampling (Figure 1).

Dissolved oxygen and temperature profiles were determined daily in the field using a combination dissolved oxygen-telethermometer unit. Total alkalinity and free carbon dioxide were measured daily titrimetrically and pH was measured with a portable pH meter. Daily chlorophyll samples were collected in a 32-ounce bottle, at each mid-lake station, utilizing a composite sampler lowered through the euphotic zone (2X Secchi disc) and immediately preserved with 10-15 drops of a 2% $MgCO_3$ suspension.

Once per survey a 32 ounce sample for hardness, alkalinity, chloride, total phosphorus, total Kjeldahl nitrogen, iron and conductivity was collected at all mid-lake stations. As well, at least one sample was collected at the major inlets and outlets. The mid-lake stations were sampled using a composite sampler through the euphotic zone. At inlets and outlets, samples were collected from 1 meter of depth using a Kemmerer sampler.

At the mid-lake stations, a sample for total phosphorus, total Kjeldahl nitrogen and iron was obtained by means of a Kemmerer sampler from a depth of 1 meter above the bottom during the July survey.

Physical, Chemical and Biological Laboratory Methods

All analyses were carried out using routine OWRC methods based on Standard Methods 13th Edition.

Iron was measured after the sample had been digested with acid to dissolve all forms of iron present.

Kjeldahl nitrogen and total phosphorus were determined after the sample was digested with acid and an oxidizing agent to destroy organic matter.

For chlorophyll determinations, 1 liter samples were filtered through a 1.2 μ membrane filter which was then extracted with 90% acetone for 24 hours. Absorbance of the extract was determined at wavelengths 600 to 750 mμ using a Unicam SP1800 ultra violet spectrophotometer. The concentrations of chlorophyll a were calculated using the equation given by Richards and Thompson (1952).

Bacteriological Field and Laboratory Methods

Two five-day bacteriolgical surveys in June, July, and a four day survey in October were completed on Big Rideau Lake. Fifty-seven surface samples were taken daily, and six depth samples at Stations 11D, 18D, 30D, 39D, 40D and 43D.

Surface samples were collected at a depth of one metre below the surface using sterile, autoclavable polycarbonate 250 ml bottles. Depth samples were collected one metre above the bottom using a modified "piggy back" sampler and sterile 237 ml evacuated rubber air syringes.

All samples were stored on ice and delivered to the mobile laboratory within two to six hours and analyzed for total coliforms, fecal coliforms and fecal streptococcus using the membrane filtration (MF) technique (Standard Methods, 13th Edition) except that m-Endo Agar Les (Difco) was used for total coliform and MacConkey membrane broth (Oxoid) was used for fecal coliform determinations. The total coliforms (TC), fecal coliforms (FC) and fecal streptococci (FS) were used as "indicators" of fecal pollution. The "indicators" are the normal flora of the large intestine, and are present in large numbers in the feces of man and animals. When water is polluted with fecal material, there is a potential danger that pathogens or disease causing microorganisms may also be present.

The coliform group is defined, according to Standard Methods, 13th Edition as "all of the aerobic and facultative anaerobic, gram-negative, non-sporeforming rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C and, or "all organisms which produce a colony with a golden-green metallic sheen within 24 hours of incubation" using the MF technique. This definition includes, in addition to the intestinal forms of the *Escherichia coli* group, closely related bacteria of the genera *Citrobacter* and *Enterobacter*. The *Enterobacter* - *Citrobacter* groups are common in soil, but are also recovered in feces in small numbers and their presence in water may indicated soil runoff or, more important, less recent fecal pollution since these organisms tend to survive longer in water than do members of the *Escherichia* group, and even to multiply when suitable environmental conditions exist. A more specific test for coliforms of intestinal origin is the fecal coliform test, with incubation of the organisms at 44.5°C. Though by no means completely selective for *Escherichia coli*, this test has proved useful as an indicator of recent fecal pollution.

Fecal streptococci (or enterococci) are also valuable indicators of recent fecal pollution. These organisms are large, ovoid, gram-positive bacteria, occurring in chains. They are normal inhabitants of the large intestine of man and animals, and they generally do not multiply outside the body. In waters polluted with fecal material, fecal streptococci are usually found along with coliform bacteria, but in smaller numbers, although in some waters they may be found alone. Their presence, along with coliforms, indicates that at least a portion of the coliforms in the sample are of fecal origin.

Bacteriological Statistical Methods

Fluctuations in bacterial concentrations due to changing environmental conditions require that a great number of samples be taken to arrive at a mean value which is representative of a specific sample location or sampling area. The most appropriate mean for bacterial levels and this type of data is the geometric mean. The vast quantities of bacteriological data generated from these samples necessitated the development of additional statistical methods to summarize the mean results into a more concise presentation. The statistical methods used are based on the analysis of variance. The stations on the lake can be grouped, by this method, into areas or groups of stations within the same statistical bacterial level, without the bias normally associated with manual interpretation.

The analysis of variance is particularly effective where bacterial concentrations vary slightly throughout the lake. Areas or stations with slight differences in bacterial concentration may be isolated. Areas or stations with statistically higher bacterial numbers reliably indicate an input.

The results from all the analyses were organized as replicates representing the stations during the survey period. All data were transformed to logarithms (base 10) and all further analyses were done using these transformed data. A geometric mean (the antilogarithm of the average of the logarithm) was calculated on each station and for each parameter. The validity of the analysis of variance program (ANOVA-CRE; Burger, 1972), was based on the assumptions that the variances of all the stations were similar (Bartlett's test of Homogeneity) and that the data were normally distributed.

Both of these assumptions were checked on Big Rideau Lake. The Bartlett's test was found to be non-significant and the data followed a normal distribution, hence the analysis of variance (F-test, Sokal, 1969) was calculated on all stations.

If the F was significant, then the multiple-t test was used to help determine the stations which should be deleted from the overall group to yield a

homogeneous group of stations. The withdrawn stations were regrouped with respect to geographic proximity and similar means. The calculations on all groups were repeated using the analysis of variance program until each discrete group was homogeneous. The homogeneous groups that were geographically isolated were compared by means of the Student-t test (using the log GM and S.E.) which indicated the statistical difference between these groups. The Student-t test was also used to compare the grouped bacteriological data from the three surveys.

DISCUSSION OF RESULTS

Temperature and Dissolved Oxygen

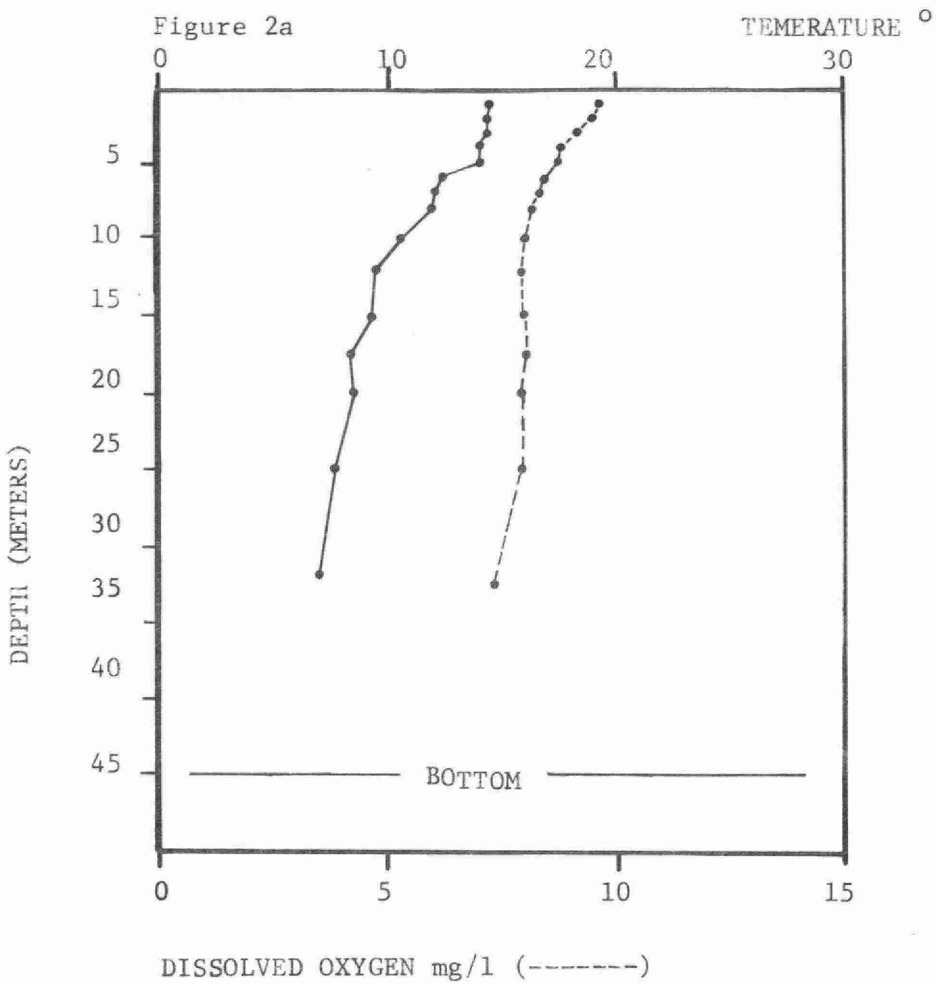
During the survey conducted in early June, thermal stratification was observed only at Station 57; the remaining three mid-lake stations were characterized by gradual temperature declines with depth (Figure 2a). Dissolved oxygen concentrations, which differed by 2.4 mg/l between surface and bottom waters, were sufficient to maintain aquatic life.

By the end of July, a well-defined thermocline or zone of rapid temperature decline was apparent at Stations 18 and 57 between 9 and 15 m of depth (Figure 2b). This temperature zone serves as a physical barrier to mixing between the warm upper waters (epilimnion) and the cool bottom waters (hypolimnion). At Station 57, the minimum oxygen concentrations were located in the thermocline or zone of rapid temperature decline (Figure 2b), indicating the presence of decomposition processes and biological respiration at that depth. At the two shallow stations (58 and 59), thermal stratification did not develop and oxygen concentrations declined gradually with depth, indicating the effects of vertical mixing processes.

During the October survey, the thermocline was slightly deeper than during preceding surveys (Figure 3). This phenomenon as well as the cooler surface water temperatures were in keeping with the expected seasonal changes characteristic of inland recreational lakes. Oxygen concentrations in the bottom strata ranged from 5.1 to 8.5 mg/l and indicate that the deep-water oxygen regime is suitable for cold-water species of game fish such as lake trout, whitefish and herring. Relatively uniform temperature and dissolved oxygen values, with respect to depth, were observed at Stations 58 and 59.

pH, Free Carbon Dioxide and Total Alkalinity

The mean surface pH values for mid-lake stations were 8.4, 8.6 and 8.5 for the June, July and October surveys respectively. In general, the pH was higher in the surface waters than in the deeper strata. For example, on July 31, at



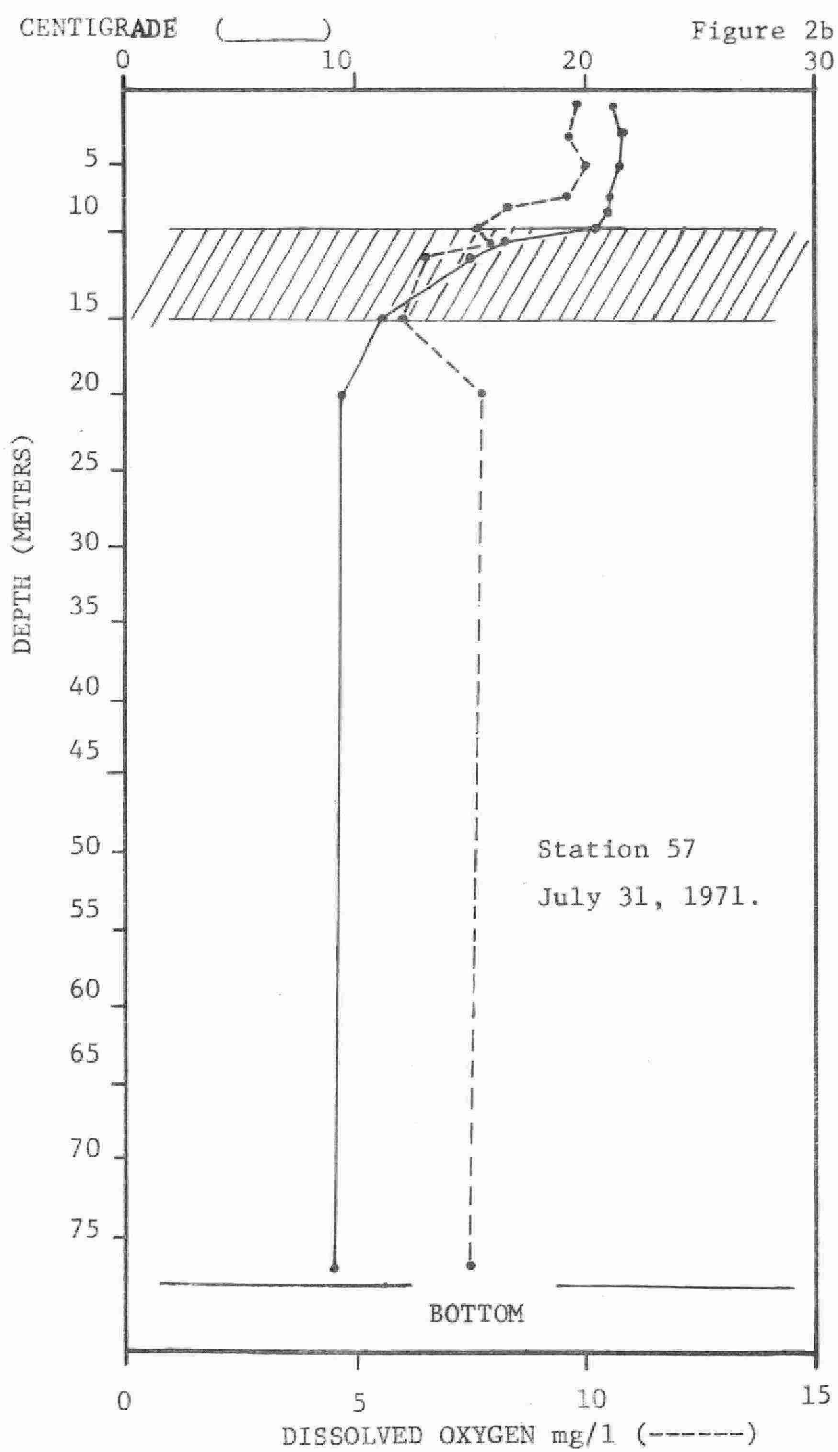


Figure 2: Temperature and dissolved oxygen profiles in Big Rideau Lake (a) Station 18 for June 5, 1971, and (b) Station 57 for July 31, 1971. The shaded area approximates the position of the thermocline.

Figure 3

Temperature ° Centigrade (———)

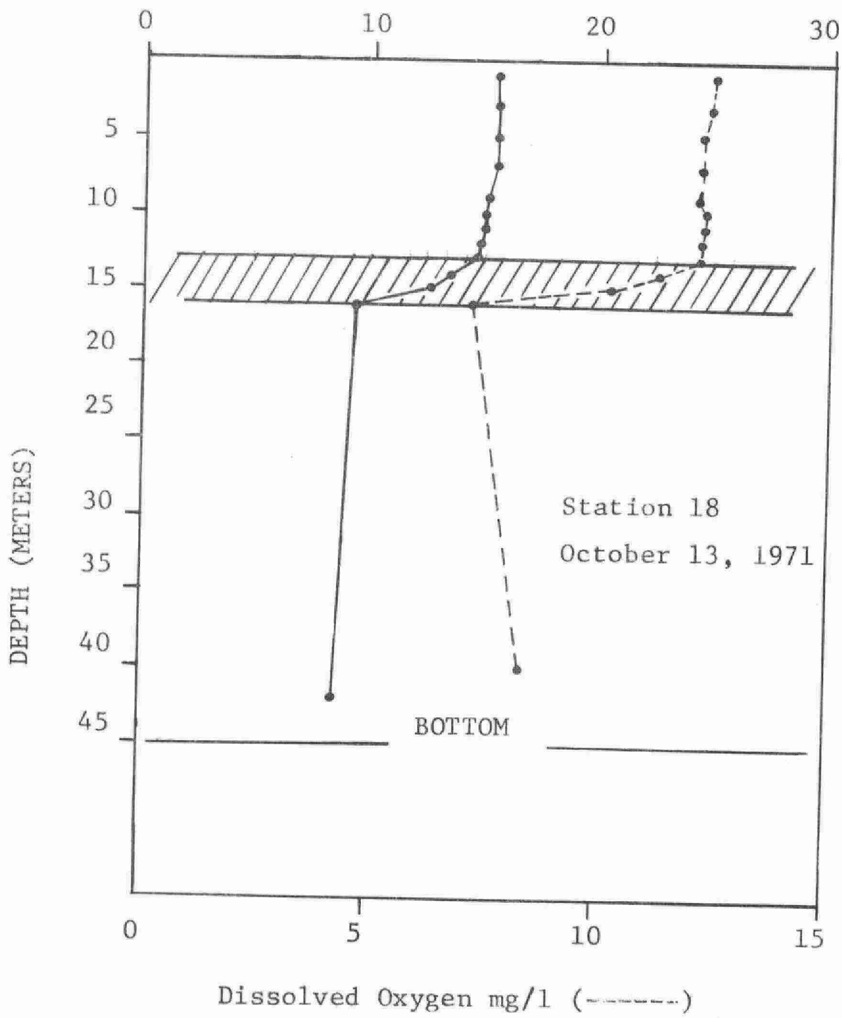


Figure 3: Temperature and dissolved oxygen profile in Big Rideau Lake, Station 18, for October 13, 1971. The shaded area approximates the position of the thermocline.

Station 18, values at 1 and 46m were 8.7 and 7.6 respectively. Surface pH values during the July and October surveys were usually in excess of the criteria (8.3) considered to be suitable for most water-oriented recreational activities. High pH concentrations could cause eye irritation to bathers.

The carbon dioxide concentrations of surface waters were low throughout the three surveys while bottom water values were moderately high when conditions of thermal stratification were present. Specifically, at Station 57 on June 3, concentrations were 0.0 and 6.3 mg/l at 1 and 69m respectively. The moderately high deep-water carbon dioxide levels were related to conditions of organic decomposition.

Total alkalinity values were moderately high indicating the relatively hard-water nature of the lake. Values were similar at both the surface and bottom strata, and generally varied by 3 mg/l or less. For example, on August 1 at Station 58, values were 106 and 105 mg/l at 1 and 15m respectively.

Hardness, Chloride, Conductivity and Iron

The hardness, chloride and conductivity data (Table 1) were consistent with each other indicating that no unusual mineral characteristics were present. The hardness is such that detergents containing phosphates are desirable for washing purposes and if such detergents are used by cottagers, every effort should be made to ensure that the waste disposal systems do not allow any phosphorus to gain access to the lake.

The iron concentrations (Table 1) were uniformly low which is normal for this type of lake.

Kjeldahl Nitrogen and Total Phosphorus

The surface concentrations of Kjeldahl nitrogen and total phosphorus were low and would not be expected to support nuisance levels of algae.

Concentrations of nitrogen and phosphorus reached 0.98 and 0.092 mg/l respectively in the bottom water at Station 59 in July and these high values are likely due to organic matter settling out of the surface water and possibly some recycling from the sediments. It is unlikely that this deep-water nutrient accumulation will create any algal problems following the autumn turnover because the great depth of water retards any return to the surface and tends to greatly dilute the nutrients.

Chlorophyll a

Algal levels, are reflected by chlorophyll a concentrations, were low during all three surveys. Values ranged from 0.6 to 1.9 µg/l, 1.1 to 2.4 µg/l and 2.6 to 4.1 µg/l for the June, July and October surveys respectively. The algal densities measured would not be expected to cause a reduction in water oriented recreational activities or diminish the aesthetic quality of the lake.

As indicated above, chlorophyll a measures the amount of photosynthetic green pigment in algae while water clarity which is one of the more important parameters used in defining water quality is determined using a Secchi disc. Recently, Brown (1972) has indicated that a near-hyperbolic relationship exists between chlorophyll a concentrations and Secchi disc readings for lakes of Precambrian origin. Figure 4 describes the author's mathematical relationship between chlorophyll a and Secchi disc for 945 sets of data collected from approximately sixty recreational lakes located primarily in Southern Ontario. Points for eutrophic lakes which are characterized by high chlorophyll a concentrations and poor water clarity are situated along the vertical axis while oligotrophic waters which have low chlorophyll a levels and allow significant light penetration are along the horizontal limb. Data for mesotrophic lakes would be dispensed about the middle section of the curve. The slightly enriched nature of Big Rideau Lake is indicated by its close proximity to values computed for Lake Ontario and the Eastern basin of Lake Erie, two oligotrophic to early mesotrophic bodies of water. However, the lake was well removed from the highly enriched Bay of Quinte, Riley Lake, Gravenhurst Bay and the Western basin of Lake Erie.

Bacteriology

Big Rideau Lake was generally well within the OWRC criteria for total body contact recreational use (OWRC, 1970).

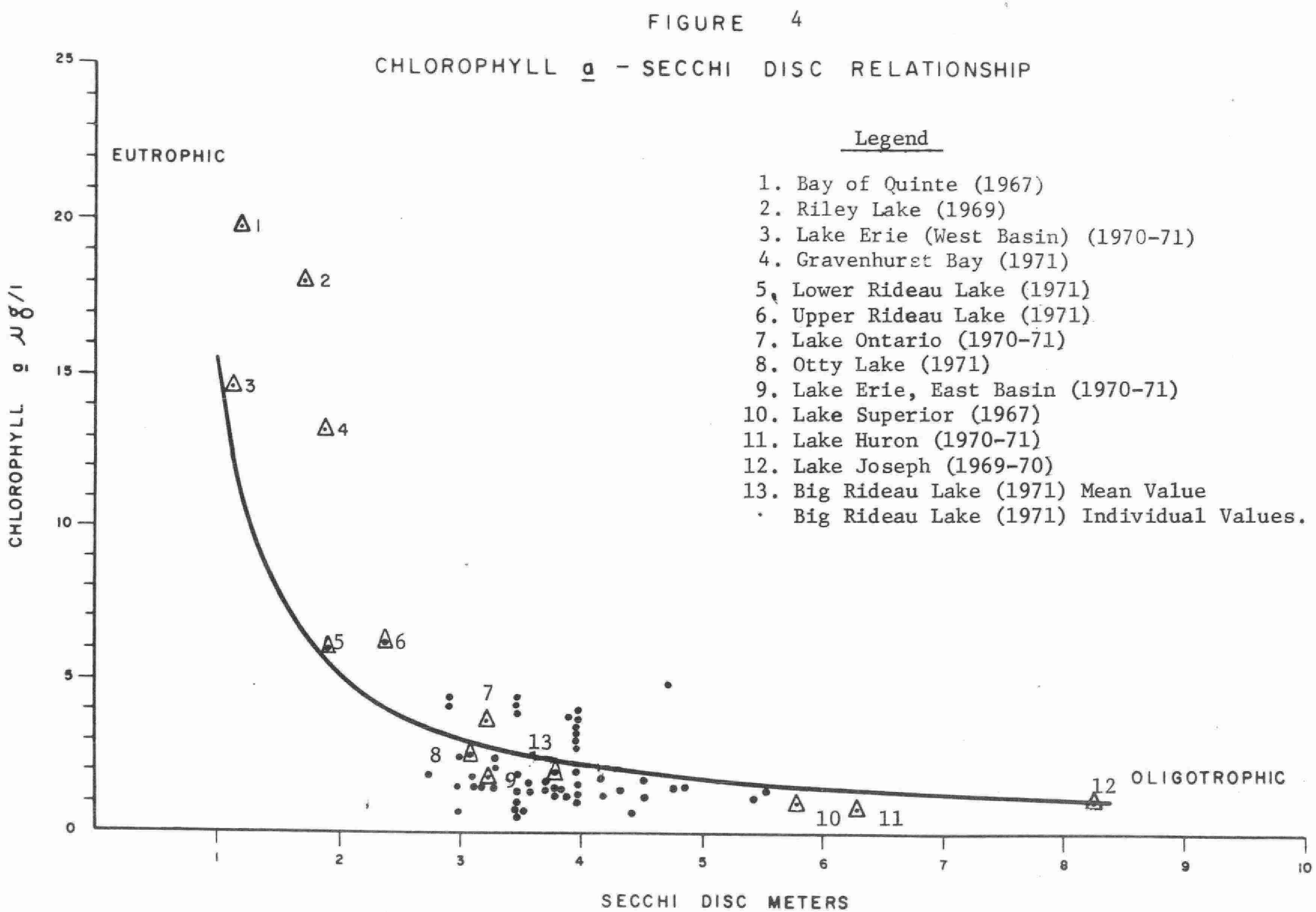


Figure 4: The relationship between chlorophyll a and Secchi disc as determined from the recreational lakes surveyed in 1971, as well as the individual and overall mean values of chlorophyll a - Secchi disc for Big Rideau Lake, are presented. The values for the GreatLakes were added for comparitive purposes.

During the June survey the overall geometric mean bacterial levels for most of the lake (Group A) were: 3 TC/100 ml, 1 FC/100 ml and 1 FS/100 ml. Group B, near Rideau Ferry, with 20 TC/100 ml and Station 2 with 3 FC/100 ml had significantly higher bacterial levels than Group A (Figure 5, Tables 4 and 5). Group C with 14 TC/100 ml, Group B with 4 FC/100 ml, and Station 35 with 6 FS/100 ml, all adjacent to the town of Portland were significantly higher than Group A (Figure 5). Slightly higher TC levels were observed at Stations 12, 20 and 27 and a slightly higher FC mean was observed at Station 14.

During the July survey, the majority of Big Rideau Lake was included in Group A with overall geometric mean bacterial levels of 11 TC/100 ml, 1 FC/100 ml and 2 FS/100 ml. Group B, the area adjacent to Rideau Ferry again indicated a significant bacterial input (Figure 6) with 144 TC/100 ml, Station 2 with 9 FC/100 ml and 37 FS/100 ml and Station 5 with 6 FC/100 ml, all within Group B, were also higher than Group A. Station 35 near the town of Portland had a higher FC level of 4/100 ml & Group C, with 15 FS/100 ml had slightly higher FS levels than Group A.

During the October survey the overall geometric mean bacterial levels were: 14 TC/100 ml, 1 FC/100 ml and 2 FS/100 ml. The lake was bacteriologically homogeneous except for Group B (Stations 33, 34 and 35) near the town of Portland with 22 FS/100 ml and Station 27 in Bellows Bay with 100 FS/100 ml both exceeding the FS recreational use criteria. However, these high FS concentrations are not considered potentially hazardous since these high concentrations were not accompanied by a corresponding increase in either TC or FC.

Generally, the overall bacteriological water quality of Big Rideau Lake appeared to be good and showed a slight improvement over the bacteriological water quality observed during the 1970 Water Quality Survey (OWRC, 1970). The areas of high bacterial levels and poorer water quality noted in the 1970 survey (OWRC, 1970) still exist around the communities of Portland and Rideau Ferry.

Although, Big Rideau Lake is within the Recreational use criteria, no surface water is considered potable without prior treatment including disinfection.

FIGURE 5 JUNE SURVEY


RIDEAU LAKE
HWY 15
PORTLAND
35
FC 4/100 ML
SHEEP I.
JERRY I.
COW I.
MORRIS I.
CHARMICHAEL
GRAPE I.
GREEN BAY
SHELDON BAY
CHICADEE I.
EXE I.
BIG I.
CORDWOOD I.
HOWELL I.
MINNOW BAY
BRITON BAY
BELLOWS BAY
CEDARS PT.
GRINDSTONE I.
MURPHY BAY
SHERWOODS PT.
SCOTCH PT.
FANCY FREE I.
LONG ISLAND
HOUGHTON BAY
MILL POND
TAR I.
TURNIP I.
TROUT I.
HUDSON BAY
BEAVER BAY
SAND I.
NARROWS BAY
NARROWS LOCK
FLOW
UPPER RIDEAU LAKE
BASS LAKE
HOGG I.
FLOW
RIDEAU FERRY
SUNKEN I.
2
FC 9/100 ML
FS 37/100 ML
5
FC 6/100 ML
GROUP C
FS 15/100 ML
GROUP A
TC 11/100 ML
FC 1/100 ML
FS 2/100 ML
GROUP B
TC 144/100 ML
HORSESHOE BAY
LITTLE BOYS CAMP COVE
47
FS 8/100 ML
BASS BAY
HOGG BAY
DAM
BLACK CREEK
LOON L.
STAR I.
FAIRCLOUGH I.
GEM I.
BLUFF I.
BIRCH I.
FERGUSON
LITTLE JOHN I.
NOBLE BAY
FOX I.
ADAM LAKE
D 18
TC 5/100 ML
19
TC 5/100 ML
LEGEND
GROUP OR STN
TC GM/100 ML
FC GM/100 ML
FS GM/100 ML
43 — BACTERIOLOGICAL STATION
D — DEPTH STATION
ONTARIO WATER RESOURCES COMMISSION
1971 RECREATIONAL LAKES PROGRAM
RIDEAU LAKE
SCALE: 1" = 3000 FEET
DRAWN BY: R.S.
DATE: MAY 1971
CHECKED BY:
DRAWING Nº: 71-44-DE


FIGURE 7 OCTOBER SURVEY
RIDEAU LAKE
HWY 15
PORTLAND
GROUP B
FS 22/100 ML
SHEEP I.
JERRY I.
COW I.
MORRIS I.
CHARMICHAEL
GRAPE I.
GREEN BAY
SHELDON BAY
40 D
TC 3/100 ML
CHICADEE I.
EXE I.
BIG I.
CORDWOOD I.
HOWELL I.
MURPHY BAY
GRINDSTONE I.
MINNOW BAY
BRITON BAY
27
TC 100/100 ML
BELLOWS BAY
CEDARS PT.
SCOTCH PT.
FANCY FREE I.
LONG ISLAND
SHERWOODS PT.
HOUGHTON BAY
BASS LAKE
MILL POND
TROUT I.
TAR I.
TURNIP I.
BEAVER BAY
HUDSON BAY
GROUP A
TC 14/100 ML
FC 1/100 ML
FS 2/100 ML
FLOW
HOGG I.
RIDEAU FERRY
SUNKEN I.
STAR I.
FAIRCLOUGH I.
FERGUSON I.
LITTLE JOHN I.
GEM I.
BLUFF I.
BIRCH I.
NOBLE BAY
FOX I.
HOGG BAY
DAM
BLACK CREEK
LOON L.
ADAM LAKE
HORSESHOE BAY
BASS BAY
LITTLE BOYS CAMP COVE
SAND I.
NARROWS BAY
NARROWS LOCK
UPPER RIDEAU LAKE
LEGEND
GROUP OR STN
TC GM/100 ML
FC GM/100 ML
FS GM/100 ML
43 — BACTERIOLOGICAL STATION
D — DEPTH STATION
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RIDEAU LAKE
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EXPLANATION OF TERMS IN BACTERIOLOGICAL TABLES

F	-	the calculated analysis of variance statistic on F ratio.
df	-	degrees of freedom of the F ratio for "between group" and "within group" variation.
F(5%)	-	the F ratio from a statistics table (Rohlf 1969). If the calculated F is greater than the F(5%), a significant difference (SD) occurred between the groups in the analysis. If the F is less than F(5%), no significant difference (NSD) occurred.
log GM	-	the logarithm (base 10) of the geometric mean.
S.E.	-	the standard error of the log GM where

$$S.E. = \frac{s}{\sqrt{n}} \quad \text{and } s = \text{standard deviation}$$

N	-	the number of values in the mean.
GM	-	the geometric mean of the bacterial level.
t	-	the calculated test of significance or student t-test used to compare stations, groups and a survey.

If t for the number of degrees of freedom shown is greater than the critical t value, a significant difference (SD) occurs.

SD refers to a significant difference at the .05 level but no significant difference at the .01 level.

SD* refers to a significant difference at the .01 level but no significant difference at the .001 level.

SD** refers to a significant difference at the .001 level.

TABLE 1

Iron, Hardness (Hard), Total Phosphorus (P), Total Kjeldahl Nitrogen (N), Chloride (Cl) and Conductivity (Cond) for Big Rideau Lake, 1971. Results are expressed in mg/l except conductivity which is μmhos/cm^3.

Station	Depth	Date	Iron	Hard.	P	N	Cl	Cond.
1	1m	6/6	0.05	106	0.020	0.34	4	-
1	1m	2/8	0.05	106	0.018	0.38	5	210
1	1m	27/10	0.20	106	0.018	0.30	4	215
18	7.6m comp	3/6	<0.05	108	0.020	0.40	4	-
18	7.4m comp	4/6	<0.05	108	0.020	0.55	5	-
18	6.6m comp	29/7	0.05	108	0.020	0.34	4	212
18	39m	29/7	-	-	0.016	0.25	-	-
18	8m comp	27/10	0.05	106	0.018	0.45	4	-
19	1m	6/6	<0.05	108	0.14	1.1	6	-
20	1m	6/6	0.05	102	0.020	0.38	5	-
31	1m	6/6	<0.05	112	0.014	0.35	6	-
52	1m	6/6	0.10	108	0.035	0.51	4	-
52	1m	29/7	0.05	106	0.026	0.44	5	211
52	1m	2/8	0.05	106	0.014	0.33	5	205
52	1m	27/10	0.05	106	0.014	0.39	5	-
57	7.6m comp	3/6	<0.05	108	0.021	0.52	5	-
57	7.6m comp	29/7	0.05	108	0.016	0.32	8	215
57	79m	29/7	-	-	0.048	0.38	-	-
57	9m comp	27/10	0.05	106	0.017	0.37	4	-
58	7.2m comp	3/6	< 0.05	126	0.019	0.48	5	-
58	6m comp	29/7	0.05	108	0.018	0.32	4	212
58	9.5m	29/7	-	-	0.016	0.34	-	-
58	9m comp	27/10	0.05	106	0.014	0.41	5	-
59	7m comp	3/6	< 0.05	108	0.020	0.44	5	-
59	6m comp	4/6	0.05	108	0.021	0.37	5	-
59	5.6m comp	29/7	0.05	108	0.016	0.35	4	213
59	17m	29/7	-	-	0.092	0.98	-	-
59	8.8m comp	27/10	0.10	106	0.016	0.75	4	-
60	1m	6/6	0.10	112	0.40	0.51	4	-

< means "less than"

"Comp" means a composite sample taken through the depth indicated.

TABLE 2 BIG RIDEAU

	Station 18		Station 57		Station 58		Station 59	
	Chlor a	S.D.	Chlor a	S.D.	Chlor a	S.D.	Chlor a	S.D.
June 3	1.4 μg/l	3.8m	1.7 μg/l	3.8 m	1.6 μg/l	3.6 m	1.2 μg/l	4.0 m
" 4	1.4	1.9	1.9	3.5	1.9	4.2	1.4	3.7
" 5	0.8	3.5	0.6	3.5	0.6	4.4	0.6	3.0
" 6	0.8	3.5	1.1	4.5	1.3	4.3	0.9	3.5
" 7	0.9	4.0	1.3	3.8	1.1	3.9	1.4	3.6
July 29	1.4	3.3	1.2	3.8	1.4	3.0	1.8	2.8
" 30	1.6	4.8	1.5	5.5	1.5	4.7	1.8	3.2
" 31	1.7	4.5	1.1	4.2	1.1	5.4	1.4	3.3
August 1	1.5	3.7	2.1	4.2	1.5	4.8	2.4	3.3
" 2	1.4	3.2	1.6	4.0	1.2	3.5	2.4	3.0
" 14	2.0	4.0	-	-	-	-	-	-
" 15	2.3	3.3	-	-	-	-	-	-
October 13	3.5	4.0	1.6	4.0	2.7	4.0	3.0	4.0
" 14	4.0	3.5	3.8	4.0	3.7	4.0	4.0	3.0
" 15	3.2	4.0	3.8	3.5	4.1	3.5	4.1	3.0
	27.9	56.8	24.3	52.3	23.7	53.3	26.4	43.4
Mean	1.86	3.79	1.87	4.02	1.82	4.10	2.03	3.34

Overall Chlor a 1.89 μg/l

S.D. 3.81 m

TABLE 3

BIG RIDEAU LAKE

ANALYSIS OF VARIANCE SUMMARY OF GROUPS

PARAMETER - TOTAL COLIFORM

Survey	June 3 - 7	July 29 - Aug. 2	Oct. 12 - 16
Group Run 1	Total Lake	Total Lake	Total Lake
F	3.2008	2.0078	1.3483
df	61,247	65,262	49,147
$F_{5\%}$	1.32	1.32	1.35
	-SD	-SD	-NSD

Group	Group A (All stations but) (1,2,3,12,20,27,) (33-36)	Group A (All stations but) (1-5,D18,19)	Total Lake
F	1.1679	1.2900	1.3483
df	51,207	58,234	49,147
$F_{5\%}$	1.35	1.32	1.35
	-NSD	-NSD	-NSD
log G.M.	0.4393	1.0314	1.1317
S.E.	0.0290	0.0466	0.0452
N	259	293	197
G.M.	3	11	14

TABLE 3 (CONT'D)

BIG RIDEAU LAKE

TOTAL COLIFORM

Group	June Group B (St.1,27)	July Group C (St.1,-5)
F	0.126	0.6187
df	2,12	4,20
$F_{5\%}$	3.887	2.87
	-NSD	-NSD
log G.M.	1.3053	2.1591
S.E.	0.1458	0.1593
N	15	25
G.M.	20	144

Group	Group C (St.33-36)
F	2.142
df	3,16
$F_{5\%}$	3.244
	-NSD
log G.M.	1.1422
S.E.	0.1000
N	20
G.M.	14

TABLE 4

BIG RIDEAU LAKE

ANALYSIS OF VARIANCE SUMMARY OF GROUPS

PARAMETER - FECAL COLIFORM

Survey	June 3 - 7	July 29 - Aug 2	Oct. 12 - 16
Group Run 1	Total Lake	Total Lake	Total Lake
F	2.0670	1.9025	0.9635
df	61,250	65,259	49,147
$F_{5\%}$	1.32	1.32	1.35
	-SD	-SD	-NSD

Group	Group A (All Stations) (but 2,14,34-) (36)	Group A (All Stations) (but 2,5,35)	Total Lake
F	1.1825	0.7780	0.9635
df	56,227	62,247	49,147
$F_{5\%}$	1.33	1.32	1.35
	-NSD	-NSD	-NSD
log G.M.	0.0369	0.0535	0.0046
S.E.	0.01007	0.0135	0.0034
N	284	310	197
G.M.	1	1	1

TABLE 4 (CONT'D)

BIG RIDEAU LAKE

FECAL COLIFORM

	June	July	October
Group	Group D (St.34,35)		
F	0.0647		
df	1,8		
$F_{5\%}$	5.32 -NSD		
log G.M.	0.6089		
S.E.	0.1775		
N	10		
G.M.	4		

TABLE 5.

BIG RIDEAU LAKE

ANALYSIS OF VARIANCE SUMMARY OF GROUPS

PARAMETER - FECAL STREPTOCOCCUS

Survey	June 3 - 7	July 29 - Aug. 2	Oct. 12 - 16
Group Run 1	Total Lake	Total Lake	Total Lake
F	1.3474	2.0906	1.5685
df	61,247	65,259	49,147
$F_{5\%}$	1.32	1.32	1.35
	-SD	-SD	-SD

Group	Group A (All stations) (but 35)	Group A (All stations) (but 2,9,10,47)	Group A (All stations) (but 27,33-35)
F	1.1912	1.2505	0.9189
df	60,244	61,243	44,130
$F_{5\%}$	1.32	1.32	1.36
	-NSD	-NSD	-NSD
log G.M.	0.1192	0.3200	0.2857
S.E.	0.0166	0.2747	0.0465
N	305	305	175
G.M.	1	2	2

TABLE 5 (CONT'D)

BIG RIDEAU LAKE

FECAL STREPTOCOCCUS

	June	July	October
		Group C (St.9,10)	Group B (St.33-35)
F		0.00004	0.1006
df		1,8	2,12
$F_{5\%}$		5.32	3.89
		-NSD	-NSD
log G.M.		1.1629	1.3361
S.E.		0.2539	0.2713
N		10	15
G.M.		15	22

GLOSSARY OF TERMS

ALKALINITY
: The alkalinity of a water sample is a measure of its capacity to neutralize acids. This capacity is due to carbonate, bicarbonate and hydroxide ions and is arbitrarily expressed as if all of the neutralizing capacity was due to calcium carbonate alone.

ANOXIC
: Refers to conditions when no oxygen is present.

BACKGROUND COLONIES
: Background colonies are other lake water bacteria capable of growing on the total coliform plate, in spite of the inherent restrictive conditions.

CHLORIDE
: Chloride is simply a measure of the chloride ion concentration and is not a measure of chlorination.

CHLOROPHYLL *a*
: A green pigment in plants.

CONDUCTIVITY
: Conductivity is a measure of the waters ability to conduct an electric current and is due to the presence of dissolved salts.

DIATOMS
: Unicellular plants found on all continents and in all types of water where light and nutrients are sufficient to support photosynthesis. They are comprised of two siliceous frustules (cell walls) which have an outer valve (epitheca) fitting over the inner valve (hypotheca) like the lid on a box. The siliceous deposits comprising the frustules vary in regular patterns according to the individual species.

EPILIMNION
: Is the thermally uniform layer of a lake lying above the thermocline. Diagram I.

EUPHOTIC ZONE
: The lighted region that extends vertically from the water surface to the level at which photosynthesis fails to occur due to insufficient light penetration.

EUTROPHIC
: Waters containing advanced nutrient enrichment and characterized by a high rate of organic production.

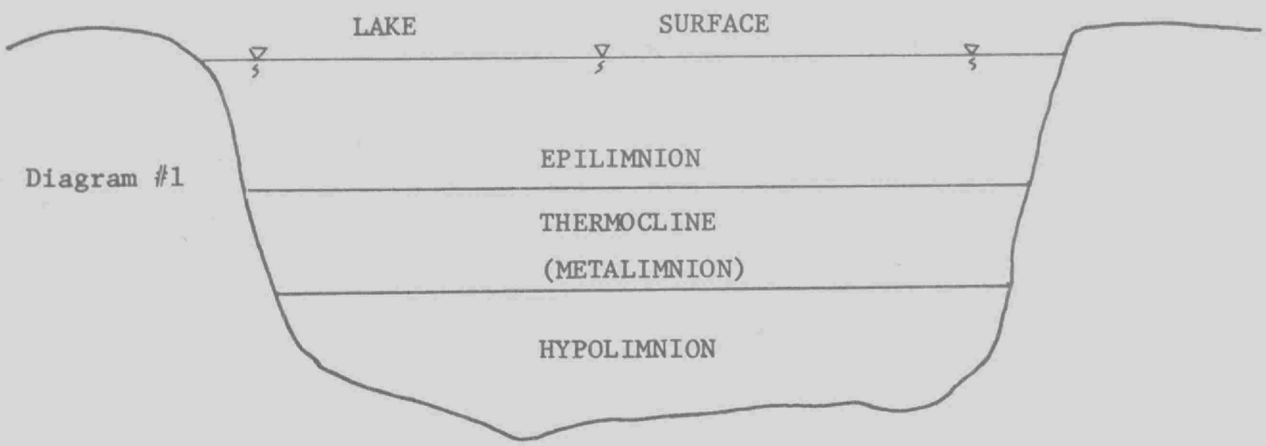
EUTROPHICATION	:The process of becoming increasingly enriched in nutrients. It refers to the entire complex of changes which accompanies increasing nutrient enrichment. The result is the increased production of dense biological growths such as algae and aquatic weeds which generally degrade water quality and render the lake unsuitable for many recreational activities.
FECAL COLIFORMS (FC)	:Fecal coliforms are bacteria associated with recent fecal pollution from man and animals.
FECAL STREPTOCOCCUS (FS)	:Fecal streptococcus are bacteria associated with fecal pollution from animals and to a lesser extent man.
HARDNESS	:Hardness of water is a measure of the total concentration of calcium and magnesium ions expressed as if all of the ions were calcium carbonate.
HYPOLIMNION	:The uniformly cold and deep layer of a lake lying below the thermocline, when the lake is thermally stratified. Diagram #1
KJELDAHL NITROGEN	:Sum of nitrogen present in the ammonia and organic forms (it does not include nitrite or nitrate).
MESOTROPHIC	:Waters characterized by a moderate nutrient supply and organic production (i.e. midway between eutrophic and oligotrophic).
METALIMNION	:See thermocline.
OLIGOTROPHIC	:Waters containing a small nutrient supply and consequently characterized by a low rate of organic production.
pH	:Is the measure of the hydrogen ion concentration expressed as the negative logarithm of the molar concentration.
PHOSPHORUS (TOTAL)	:Sum of all forms of phosphorus present in the sample.

SECCHI DISC :A circular metal plate, 20 centimeters in diameter, the upper surface of which is divided into four equal quadrants. Two quadrants directly opposite each other are painted black and the intervening ones white. The secchi disc is used to estimate the turbidity of the lake water.

THERMAL STRATIFICATION :During the spring, vertical temperatures in a lake are homogeneous from top to bottom. As summer advances, the surface waters become warmer and less dense than the underlying cooler waters. A strong thermal gradient (Thermocline) occurs giving rise to three distinct water layers. The variation in density between layers retards mixing by wind action and water currents. Diagram #1.

THERMOCLINE (metalimnion) :The layer of water located between the epilimnion and hypolimnion in which the temperature exhibits a decline equal to or exceeding $1^{\circ}C$ increase per meter.

Diagram #1



TOTAL COLIFORMS (TC) :Total coliforms are bacteria commonly associated with fecal pollution but may also be present naturally in the environment.

TROPHIC STATUS :Depending upon the degree of nutrient enrichment and resulting biological productivity, lakes are classified into three intergrading types:

TROPHIC STATUS
(continued)

:oligotrophic, mesotrophic and eutrophic. If the supply of nutrients to an oligotrophic lake is progressively increased, the lake will become more mesotrophic in character and with continued enrichment it will become eutrophic.

BIBLIOGRAPHY

BENNETT, E.A. Taken from the Great Lakes as an Environment, Edited by D.V. Anderson, Great Lakes Institute Report PR 39, University of Toronto, October 1969.

BROWN, D.J. 1972 Chlorophyll a - Secchi disc relationship in Ontario Recreational Lakes (In Preparation).

BURGER, A. Statistical Bacterial Data Summarization and Interpretation Internal OWRC Report (Unpublished).

Guidelines and Criteria for Water Quality Management in Ontario, OWRC, June 1970.

Microbiological Criteria

Water used for body contact recreational activities should be free from pathogens including any bacteria, fungi or viruses that may produce enteric disorders or eye, ear, nose, throat and skin infections. Where ingestion is probable, recreational waters can be considered impaired when the coliform, fecal coliform, and/or enterococcus geometric mean density exceeds 1000, 100 and/or 20 per 100 ml respectively, in a series of at least ten samples per month, including samples collected during weekend periods.

RICHARDS, F.A. and THOMPSON, T.G. 1952 The estimation and characterization of plankton populations by pigment analysis II. The spectrophotometric method for the estimation of plankton pigments. J. Marine Res., 11:156.

ROHLF, F.M. and SOKAL, R.R., 1969 Statistical Tables, W.H. Freeman and Company, San Francisco.

SOKAL, R.R. and ROHLF, F.J. 1969 Biometry, the principals and practices of statistics in biological research, W.H. Freeman and Company, San Francisco.

Standard Methods for the Examination of Water and Wastewater, 13th Edition, 1971. APHA, AWWA, WPCF.

Water Quality Report on Big Rideau Lake, OWRC, 1970.

The Role of some Physico-Chemical properties of water as causative agents of eye irritation of swimmers. Report on the committee on water quality criteria, U.S. Department of the Interior, 1968. P-15 - 16